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16. ABSTRACT

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DEVELOPMENT, REPLICABILITY AND MODELING OF NATURALLY DERIVED MICROCOSMS

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Experiments with naturally derived, self-developing microcosms were performed to determine the coefficients of variation for dissolved nitrogen and phosphorus, conductivity, dissolved organic carbon, pH, photosynthesis-to-respiration ratio, and final algal biomass. Ten replicate tanks each of three treatments were set up with 8 l of standard reference water. Twenty of the tanks were flow-through and ten were static. Coefficients of variation (CV) for any one sampling time for ten replicates ranged from 0 to 219 percent, but for most parameters the CV was consistently less than 20 percent.

Methoxychlor was introduced into the microcosms after 73 days to obtain preliminary information for further experiments and to test modeling techniques. The methoxychlor disappeared rapidly and produced no apparent effects on the study parameters.

INTRODUCTION

The three major reasons for this microcosm research were (1) to develop a screening technique that can be used to assess the ecological fate and effects of chemicals, (2) to obtain basic information on ecosystems under controlled experimental conditions, and (3) to evaluate the utility of microcosms in testing models. Originally, a screening technique was the major objective, but as experience was gained the other objectives emerged as having greater benefits for developing techniques for evaluating or predicting the behavior of toxicants in ecosystems.

To get basic information on ecosystem development and function, the systems used in this work were naturally derived and self-developing as compared to gnotobiotic systems. The advantage of the more complex naturally derived system is the presumed inclusion of all major ecosystem functions in a balanced relationship to each other, thereby providing the opportunity to assess system parameters.

Both continuous-flow and static systems were used in this study. Most of the work, however, was done with flowing systems because the biomass in these systems is determined by nutrient input rate independent of initial biomass levels, and because continuous input makes introduction of test chemicals more convenient for either screening or model testing.

Both philosophy and resource limitations enforced our view of the systems. We are concerned with ecosystem functions irrespective of species composition. By function we generally refer to various steps in element cycles (including transformations of toxic organics). We took what might be called a naturalistic approach. By choosing samples from a natural system (or several such systems) to obtain a broad genetic potential and allowing natural development to occur, we attempted to give the microcosms the best chance of functioning as ecosystems. Our presumption is that systems subject to similar physical and chemical conditions, even though inoculated with samples from different locations, will develop into functionally similar systems (the equifinality idea of von Bertalanffy).[1] This concept could be useful for clarifying and simplifying experiments employing microcosms. A general procedure using standard test conditions and organisms from any location would produce functionally similar microcosms, if our presumption is true.

Three sets of ten microcosms were set up, each with one of three treatments: (1) continuous-flow with standard sand substrate; (2) continuous-flow, natural sediment substrate; and (3) static, natural sediment substrate. After ten weeks development,

methoxychlor was added to five of each set of ten microcosms.

METHODS

Thirty microcosms were assembled in all-glass, 15 cm x 30 cm x 30 cm deep aquaria that had been washed, rinsed, and autoclaved. Three cm of Ottawa sand were added to 20 of the tanks and five cm were added to the other ten. The sand in each was then rinsed well with deionized water and drained.

Initial inoculation of the microcosms was accomplished on site at a 2-ha pond near the laboratory. A large quantity of pond-bottom sediments was slurried in a tub, the large debris removed, and a 2-cm layer added to each of the 20 tanks containing 3 cm of sand. Three depressions were created in the 5-cm layer of sand in each of the other ten tanks and each depression was filled with 10 ml of the slurry. Commercial plastic wrap was then used to cover the sediment or sand surface to minimize turbulence as 8 l of pond water was carefully added to each tank. The film was gently removed, and a 15-cm piece of water-soaked twig (1–2 cm diam.) was added to each tank. To obtain seston, 150 casts were made into the pond using a plankton net on a 3-m throw line. The collected organisms were mixed in a beaker and divided equally between all 30 microcosms. In an attempt to obtain the maximum genetic potential, each system was reinoculated for four successive weeks, each time from fresh plankton hauls. Each set of ten replicates was also cross-seeded weekly throughout the experiment to minimize biotic variability.

The microcosms were maintained in a temperature-controlled room cycling between 22°C at the beginning of the 12-hr light period and 26°C at the end. A bank of "Vitalite" high intensity fluorescent lights provided an intensity of 850 ± 50 foot-candles at the water surface.

The 30 microcosms were separated into three equal groups: Treatment A, Ottawa sand substrate, flowing; Treatment B, natural sediments over sand, flowing; and Treatment C, natural sediments over sand, static. Modified standard reference water[2] was continuously supplied (0.7 ml min^{-1}) to the flowing-system microcosms. Freeman's formula was modified to more closely approximate the soft-water conditions of the natural water by reducing the $MnSO_4$ by 80 percent and omitting the CaO. The resulting concentrations of the major nutrients added to the system were $NO_3 - N = 0.5$ mg l^{-1}, $NH_4 - N = 0.5$ mg l^{-1}, and $o - PO_4 - P = 0.1$ mg l^{-1}. The initial concentrations of the same nutrients in the pond water were 0.02, 0.02, and 0.015 mg l^{-1}, respectively. The systems were aerated for 15 min every 4 hr with filtered air to mix the systems. The effluent was removed via a constant-level, self starting siphon.

Several qualitative and quantitative measurements were used to assess the state of the systems. Monitoring the gross structure involved observations of overall appearance, including stratification, color, wall growth, detrital layer, clarity of water and presence of different groups of invertebrates. On a more specific scale, microbial groups were monitored through periodic sampling, preservation, and observation of plankton and algal mat communities.

Beginning with Week 12 of the study, community metabolism, in terms of photosynthesis, respiration, and photosynthesis to respiration (P/R) ratio, were estimated weekly using dissolved oxygen (DO) measurements taken with a self-stirring DO probe at the beginning and end of the light period. The common problem of correcting readings for diffusion during the measurement period was eliminated by covering the surface of each microcosm with Saran film. Weekly analyses were also performed for NH_4^+, NO_2^-, NO_3^-, and $o - PO_4^{3-}$ concentrations and dissolved organic carbon (DOC) commencing with Week 10, and for conductivity commencing with Week 12. Nitrogen, phosphorus, and carbon analyses were performed according to USEPA[3] techniques. Conductivity was measured with a conductivity meter. Dissolved oxygen and hydrogen ion activity (pH) measurements were taken at 0830 and 1600 hrs five days a week.

After 73 days, analytical grade (100 percent) methoxychlor was introduced into half the replicates of each set. An initial spike was added to both the static and the flowing systems. To 10 of the 20 microcosms with the natural sediment layer, 91.3 μg of the compound were added, and to five of the ten microcosms with only sediment plugs, 41.1 μg were added as a concentrated water solution. These amounts were calculated as the amounts that would be sorbed by the sediments and biota and still leave about 5 $\mu g\ l^{-1}$ in the water. On the same day, methoxychlor was introduced into the nutrient supply systems to give

TABLE I
Succession in continuous-flow microcosms

Time	Events
0	Turbid water (midge emergence in 3–4 days)
1–4 wks	Turbidity clears, algal bloom develops (dominant species may vary with original source but so far it has been *Ankistrodesmus* and/or *Scenedesmus*), attached growth starts on walls, filamentous algae (*Oedogonium*) appears.
6–8 wks	Bloom subsides, water clears, microinvertebrates (copepods, ostracods, annelids, in that order) become conspicuous, wall growth builds up, floating algal mat develops (up to 25 percent of surface, *Oedogonium*).
9–12 wks	Water column clears, mat covers 75 percent of surface, wall growth sloughs off, detritus builds up on bottom, microinvertebrates still present.

5 $\mu g\ l^{-1}$ flowing into five of each group of ten flow-thru tanks.

Methoxychlor in the water was monitored three times per week using isooctane extraction and gas-liquid chromatography (GLC) with electron-capture detection for quantitation. During Week 17, the 15 methoxychlor-treated microcosms were sacrificed to analyze complete compartments for the pesticide. The total algal mat was harvested and blotted dry; a 1-g sample was macerated in a ground-glass tissue homogenizer. The sample was then rinsed into a 50-ml flask with 10 ml of water and 25 ml isooctane was added. The flask was then shaken vigorously for two minutes. Wall growth samples were extracted similarly. Sediment plus detritus samples were removed with a 20-mm Plexiglas tube, placed in a 250-ml flask with 25 ml of isooctane, and shaken for 18 hrs. All samples were analyzed by GLC.

RESULTS AND DISCUSSION

It was reasoned that a toxic substance might behave differently in biotic systems of different complexity. Systems with a more varied biotic community might be expected to decompose the substance more readily (or at least with a higher probability) than those of a very limited species composition. This was the rationale for the "naturalistic" approach taken for microcosms intended for the study of toxic substances.

a. *Development and Replicability*

The general pattern of development of the flowing systems is given in Table I. Development of the static systems was similar, but slower with less biomass production. Variations in development were frequently associated with larger cladoceran populations. Phytoplankton blooms, sometimes associated with the presence of snails, caused fluctuations in all parameters because of the population irruptions and crashes characteristic of phytoplankton. Snails reproduced rapidly, quickly overgrowing the capacity of the small systems. By consuming the attached growth and thereby encouraging phytoplankton blooms, they contributed to instability in the systems. They were, therefore, killed whenever detected, and their remains were left in the tanks. Other organisms typically found in these systems are listed in Table II. Although fluctuations of conspicuous forms occur, once established, many of the forms repeatedly reappear. In microcosms held for 20 months, the appearance and disappearance of copepods, ostracods, and other forms has been repeatedly noticed.

Dissolved concentrations of basic nutrients are set by the uptake - assimilation - mineralization processes of the element cycles. Nutrient levels were therefore measured as potential indicators of differences among the systems. Typically, nutrient concentrations approached levels that remained fairly constant throughout the study period. The

TABLE II

Microorganisms present in naturally derived laboratory microcosms seeded from Athens, Georgia, pond

Organism	Number of species
Algae	
Green	>30
Blue-green	10
Dinoflagellate	1
Diatoms	7
Protozoa	
Ciliates	8
Amoeboids	5
Flagellates	6
Gastrotricha	1
Rotifera	5
Turbellaria	1
Annelida	3
Cladocera	2
Copepoda	3
Ostracoda	3

means for each treatment and the coefficients of variation for the ten samples of a treatment for any week are summarized in Table III. Although the CV vary over a considerable range, most are near the minimum values. The high values in every case are caused by a single, inordinately high value.

The data for nutrients for all microcosms for week 16 are given in Table IV to illustrate the variation encountered. It is interestig to note that the inorganic nutrient levels are similar in all treatments regardless of whether the systems are flowing (nutrients continuously added) or static. This situation is probably indicative that the internal cycling processes for inorganic nutrients are rapid compared to the dilution rate of the flowing systems. The CV are in the same range as those found by Giddings and Eddlemon.[4]

Data on P/R ratios are shown in Table V. Again there is good replicability with CV around 10–15 percent in all three groups. Photosynthesis and respiration are both lower in Treatment C and diel pH fluctuation is greater, but the P/R ratios are not significantly different. The pH values for morning and evening for the same days as the P/R data show excellent CV relationships as other workers have found. The important point is that the microcosms are very replicable within treatments in terms of P, R, P/R ratio, and pH, and have CV as low or lower than those obtained in other studies.[5,6]

Dissolved organic carbon (DOC) concentration is a result of secretions of living organisms and of partial decomposition of dead ones by the microbiota. As such, DOC would be expected to vary as a function of both autotrophic and heterotrophic activity. Its variability in replicate microcosms as well as among treatments was therefore of interest. Summary values are given in Table V. DOC concentration was decidedly higher in the

TABLE III

Overall means and ranges of coefficients of variation of nutrient data on any sampling day

n for mean = 160, n for CV = 10

Parameter	Treatment	Mean	Range of coefficients of variations (%)
$NH_3 - N$ mg N l^{-1}	A	0.10	9.5 to 36.2
	B	0.13	3.6 to 21.1
	C	0.16	10.5 to 24.9
$NO_2 - N$ mg N l^{-1}	A	0.003	0 to 33.3
	B	0.003	0 to 98.6
	C	0.004	0 to 61.6
$NO_3 - N$ mg N l^{-1}	A	0.02	0 to 144
	B	0.02	0 to 29.1
	C	0.02	0 to 65.7
$o - PO_4$ mg P l^{-1}	A	0.004	29.1 to 211
	B	0.004	21.0 to 78.8
	C	0.006	22.1 to 135

TABLE IV

Nutrient concentrations in naturally derived laboratory microcosms for Week 16 (all conc. in mg l^{-1})

Treatment	$NO_2 - N$	$NO_3 - N$	$NH_3 - N$	$O - PO_4$
	0.008	0.01	0.08	0.026
A	0.004	0.01	0.08	0.005
	0.004	0.01	0.09	0.004
	0.004	0.01	0.10	0.009
Flow,	0.004	0.02	0.12	0.004
	0.004	0.01	0.10	0.004
	0.003	0.01	0.10	0.004
Sand	0.004	0.01	0.10	0.007
	0.008	0.01	0.09	0.008
	0.002	0.01	0.07	0.003
	0.004	0.03	0.16	0.004
B	0.002	0.02	0.11	0.004
	0.002	0.02	0.13	0.005
	0.002	0.02	0.16	0.004
Flow,	0.002	0.02	0.12	0.004
	0.002	0.02	0.11	0.004
	0.005	0.02	0.16	0.006
Sediment	0.002	0.03	0.11	0.003
	0.003	0.03	0.13	0.004
	0.002	0.03	0.14	0.004
	0.004	0.03	0.13	0.005
C	0.002	0.02	0.14	0.002
	0.002	0.02	0.16	0.004
	0.004	0.02	0.12	0.003
Static,	0.004	0.02	0.20	0.003
	0.005	0.02	0.14	0.003
	0.004	0.04	0.14	0.003
Sediment	0.002	0.02	0.12	0.002
	0.007	0.02	0.19	0.007
	0.004	0.02	0.13	0.002

static system (C), possibly because dilution reduced the concentration in the flowing systems, or microbial activity might have been higher in the flowing systems. Variability within treatments was low, and if DOC is sensitive to perturbations it could prove to be a useful diagnostic parameter.

Conductivity of the influent water was a result of dissolved inorganic nutrients. Uptake and assimilation of the inorganics reduces the conductivity of the water inside the system. Conductivity, therefore, behaved in a manner opposite to that of DOC. And like DOC, it could prove to be useful diagnostic parameter because of its relationship to nutrient uptake by autotrophs.

Perhaps the most important measurement made on the microcosms was that of final biomass (algal mat plus wall growth). In the flowing systems the biomass of the algal mat, which included many organisms in addition to algae, was generally two to three times that of the wall growth. In static systems, however, the mat was much smaller than the wall growth. The mean dry weights and their CV are given in Table VI. Large differences existed within the static systems. Six systems had no measurable algal mat and two had biomass that could not be measured.

b. *Mathematical Modeling and Analysis of Methoxychlor in Microcosms*

A model designed to predict the fate of a substance in any ecosystem as a function of the descriptors of that system ought to predict the fate of a substance in a laboratory ecosystem. Recognition that laboratory ecosystems cannot simulate outdoor ecosystems strengthens their utility for our needs. If they are not simulators of ecosystems, they must be, themselves, ecosystems, albeit sustained by ar-

TABLE V

Overall means and ranges of coefficients of variation on any sampling day for conductivity, dissolved organic carbon, P/R ratio, and morning and evening pH, n for CV = 10

Parameter	Treatment	Mean	Range of coefficients of variation (%)
Conductivity	A	144	7.8 to 9.8
umho	B	128	6.1 to 12.2
n for means = 50	C	27	17.3 to 22.6
Dissolved organic	A	5.4	11.3 to 32.2
carbon, mg C l^{-1}	B	4.8	15.7 to 32.4
n for means = 70	C	11.2	13.3 to 25.1
P/R	A	1.6	9.9 to 16.3
ratio	B	1.3	8.1 to 22.0
n for means = 50	C	1.2	11.5 to 15.6
pH,	A	9.4	1.7 to 3.3
morning	B	9.0	1.4 to 5.4
n for means = 50	C	6.9	2.1 to 6.0
pH,	A	10.0	0.7 to 1.5
evening	B	9.9	0.8 to 2.3
n for means = 50	C	9.2	1.2 to 2.7

TABLE VI

Total biomass in algal mat and wall growth compartments (mean dry weight in grams)

Treatment	Algal mat	Wall growth	Total
A	3.5(23.6%)[a]	1.3(36.2%)	4.8(14.5%)
B	3.2(42.1%)	1.1(36.8%)	4.2(29.8%)
C	0.2(218%)	0.8(88%)	1.0(101%)

[a]Coefficients of variation in parentheses.

tificially controlled nutrient and energy inputs. Prediction of the fate of a chemical in a laboratory ecosystem, therefore, is one case of predicting the fate of the chemical in ecosystems.

c. *Modeling and Analysis*

The model is based upon parameters describing the toxicant physically and chemically as well as on factors describing the environment.[7] Rates of chemical transformation, partition coefficients for association with solids, and rates of physical removal from the water are used in differential equations to make the predictions. The environment for these tests, of course, is the microcosm. The structure of the simple model of methoxychlor in the microcosms is presented in Figure 1. Predictions were made of the behavior of methoxychlor in the flowing microcosms, treatment B (Figure 2). Sampling was carried through for all microcosms. The experimental data for the three treatments are shown in Figures 3 through 5. In Figure 6 both predicted and observed values are shown. The predicted values were obtained by using the information available on methoxychlor at the beginning of the experiment (Table VII). The methoxychlor disappeared much more rapidly than was expected. Disagreement between predicted and observed values indicates a deficiency in the model. The deficiency may be incorrect descriptions of processes, including the environment in which they occurred, or incorrect values of rate coefficients, or both.

Values predicted for sediment are difficult to

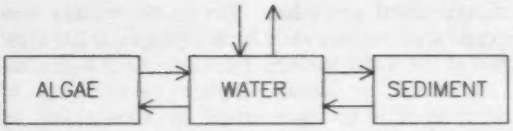

FIGURE 1 Preliminary model for methoxychlor in the microcosms.

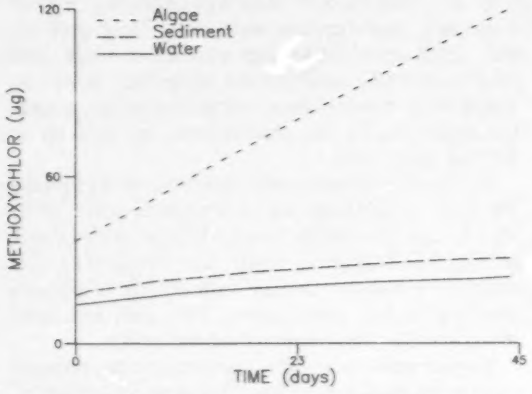

FIGURE 2 Predicted quantities of methoxychlor in the flowing microcosms (Treatment B).

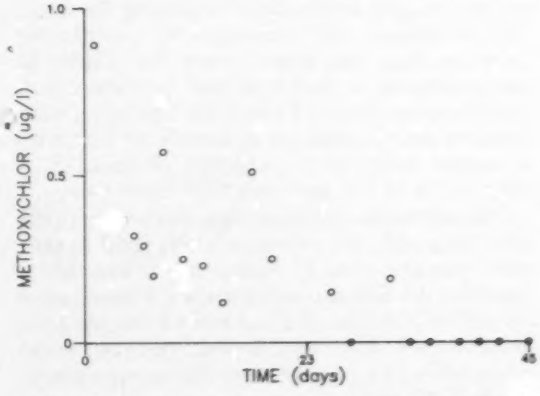

FIGURE 3 Observed methoxychlor in water for Treatment A.

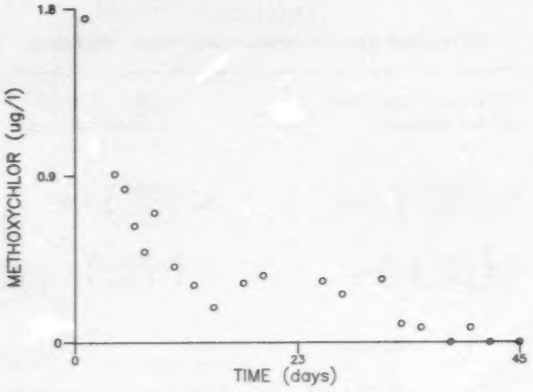

FIGURE 4 Observed methoxychlor in water for Treatment B.

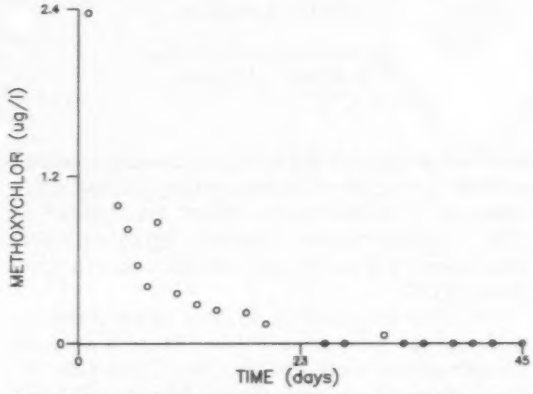

FIGURE 5 Observed methoxychlor in water for Treatment C.

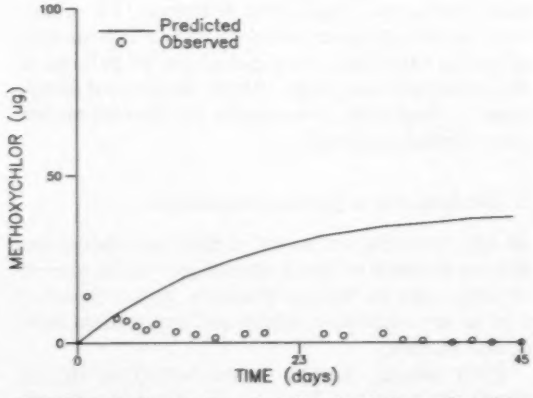

FIGURE 6 Comparison of predicted and observed methoxychlor quantities in the water.

TABLE VII
Process information for methoxychlor, initial calculations

Process rate coefficients and partitioning	→	$\frac{\mu gX}{g\ algae} / \frac{\mu gX}{g\ water}$
$K_p\left(\frac{bacteria}{water}\right) = 1800$		$K_p\left(\frac{sand}{water}\right) = 16$
$K_p\left(\frac{algae}{water}\right) = 8400$		$K_p\left(\frac{sediment}{water}\right) = 2000$

$K_{chemical} = 1.9(10^{-3})\ day^{-1}$
$K_{photochemical} = 3.9(10^{-4})\ day^{-1}$
$K_{biological} = 2.1(10^{-4})\ day^{-1}$
$K_{\text{"natural water"}} = 2.31(10^{-2})\ day^{-1}$

Effective Partitioning

K'_p (sediment) = 1.28 (water)
K'_p (algae) = 1.05 (water)

evaluate because of the lack of information on the vertical movement of methoxychlor into the sediment or on transformation within the sediments. The predicted values, however, agree with the observed only if a thin layer, on the order of 1 mm, is saturated.

Over the course of the 45 days of the methoxychlor experiment, about 194 μg of methoxychlor was introduced to the microcosms. During the 45 days, about 17 μg were exported in the effluent. At the termination of the experiment, about 1 μg was present in wall growth, about 6 μg in the algal mat, and about 7 μg in the sediment. The quantities found at the termination of the experiment, plus that exported, represent about 16 percent of the total that was added. About 84 percent disappeared, therefore, presumably by decomposition or as bound materials.

d. *Critique and a Second Hypothesis*

In any scientific endeavor, a first hypothesis and the experiment to test it are subject to the gravest doubts, even by their originators. In retrospect, it can be seen that both model and experiment were found lacking.

Poor mixing, uptake of methoxychlor by the aquarium corner adhesive, an unmeasured sediment demand, and biological parameters that were difficult to assess were recognized difficulties in the experimental procedure. The methoxychlor was introduced continuously by dripping onto the algal mat at the water surface. Because of the high concentrations, a locally higher partitioning of methoxychlor to algae could be maintained, as well as the potential microbial enrichment by encouraging organisms capable of using high concentrations of methoxychlor. There is no hard evidence that either of these phenomena occurred; nevertheless, future experiments will include subsurface injection with better mixing.

Upon observing a much more rapid disappearance of methoxychlor than was expected, several diagnostic experiments were run. Only preliminary analyses of these data have been made. The results of these analyses are revealing, however, and lead to a better comprehension of the processes occurring in the microcosms, as well as to further questions.

A silicone rubber sealant that was used to fasten the glass panels together in constructing the tanks was found to absorb methoxychlor with a rate coefficient of about 10^{-3} day^{-1} cm^{-2} (silicone). The net rate was about .06 day^{-1} for 60 cm^2 of silicone exposed in our microcosms. This sink has been minimized by modification of the tanks.

Experiments to obtain estimates of decomposition by the algal mat community were run using ^{14}C labeled methoxychlor. In these experiments weighed portions of the algal mats were introduced into beakers containing 500 ml of water into which 100 nCi of labeled methoxychlor (Table VIII) was introduced. The 8 hour concentrations were used to calculate partition coefficients ($K_p = 1{,}577 \pm 207$), between the algal mat (blotted wet weight) and water. Considering the partition coefficient and assuming that partitioning between algae and water is very fast relative to decomposition, a decomposition rate was calculated from the data of Table VIII. This process is a function of both algal mat and methoxychlor, with a second order rate coefficient of about $3 \times 10^{-4} \pm 2 \times 10^{-5}$ l mg^{-1} day^{-1}.

The sediments constitute an unknown but probably large sink. No experiment was done to estimate this rate directly. However, the rate calculated for the silicone corner sealant is based upon its exposed surface. If it is assumed that the sediments remove methoxychlor from the water at the same rate as the silicone, then the rate per microcosm is .42 day^{-1}.

If the rates obtained using the ^{14}C labeled methoxychlor are compared to those assumed prior to

TABLE VIII

Isooctane extractable ^{14}C from diagnostic experiments for biological degradation rate of methoxychlor (nCi) (means of three replicates and their standard errors)

	ALGAL BIOMASS		
DAY	.3 g/500 ml	1 g/500 ml	3 g/500 ml
1	.083 ± .0083	.041 ± .0027	.020 ± .0027
6	.054 ± .0048	.033 ± .0026	.016 ± .0040
11	.035 ± .0028	.015 ± .0013	.010 ± .0017

the experiment, it is clear that our assumed biological parameters were in error. The partition coefficient used ($K_p = 8400$ for *Chlorella pyrenoidosa*) was more than five times higher than the value indicated in the diagnostic experiment. For the decomposition rate, the only available information that could be used was a second-order rate constant[8] for *Flavobacterium harrisonii* of 1.1×10^{-13} l cell^{-1} hr^{-1}. Assuming only one active population a value of 2.1×10^{-4} day^{-1} per microcosm was calculated (Table VII). It was assumed initially that a thin upper layer of the sediment would saturate and remain in equilibrium with the water. The net effect of all these assumptions resulted in the overestimation noted.

Using the results of the preliminary analyses of the diagnostic experiments to make a retrospective calculation, values of .3 μg l^{-1} of dissolved methoxychlor and a total of 19.5 μg on the algal mat are obtained. These values, although somewhat high, are a vast improvement over the preliminary values.

Our retrospective calculations constitute a second hypothesis about the fate of methoxychlor in the systems. All the loss rates calculated from the ^{14}C labeled experiments, used in the second hypothesis are probably low, because they are based on total ^{14}C that was extracted, including any extractable decomposition products. Analysis for the parent compound by gas chromatography probably will significantly increase these rates.

Even using these rates, the biological degradation rate obtained from the algal mat community is higher than expected based upon the difficulty experienced by Paris *et al.*[8] in obtaining degrading populations. If only a few populations are able to degrade methoxychlor in pure culture, perhaps there is a community effect that will account for the high rates of the system. Senior, Bull, and Slater[9] found such symbiotic effects in which the herbicide Dalapon was degraded by a microbial community, but sustained degradation was not carried out by any of the populations alone. Naturally derived laboratory ecosystems are expected to exhibit these phenomena, although in some cases it might be necessary to select the community in the presence of the xenobiotic compound.

CONCLUSIONS

The microcosms are sufficiently replicable to be useful as laboratory ecosystems. Several parameters were identified as potentially useful for diagnostic purposes when effects are suspected.

Using information available prior to the experiment, the concentrations of methoxychlor were significantly overestimated. The difficulty of making calculations of expected environmental concentrations using isolated data from single species was reflected in these estimates. Preliminary estimates of biological decomposition rates derived from experiments using ^{14}C labeled methoxychlor indicate much higher rates by the algal mat community than was previously known.

Calculation of values that approach those observed included an assumption of a significant uptake rate by the sediments. Future experiments should quantify this rate. Microcosms with a high water to sediment ratio should be used for studying hydrophobic compounds, if reactions in the water are of primary interest.

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DISCLAIMER

The use of trade or proprietary names and products in this publication is intended for the information of the reader and does not indicate that such are recommended in preference to related and equivalent materials.

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